NAVAL PERSONNEL PROGRAM SUPPORT ACTIVITY

PERSONNEL RESEARCH LABORATORY

WRM NO. 66-5

JULY 1965

A PRELIMINARY STUDY OF MAN IN THE SEA
DIVER PERSONNEL AND TRAINING IMPLICATIONS

BY

A. S. PROPST

AN ACTIVITY OF THE BUREAU OF NAVAL PERSONNEL

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ALTHOUGH PERSONNEL RESEARCH MEMORANDA IN THE AREA OF NEW WEAPONS AND SUPPORT SYSTEMS CONTAIN THE BEST AVAILABLE PRELIMINARY INFORMATION, SOME REVISIONS MAY BE REQUIRED AS THE TECHNICAL DEVELOPMENT OF THE SYSTEMS PROGRESSES.

THE CONCLUSIONS AND RECOMMENDATIONS ADVANCED ARE FOR INFORMATION PURPOSES. POLICY CONSIDERATIONS AS WELL AS PLANNING FACTORS ARE APPLIED PRIOR TO IMPLEMENTATION. THEREFORE, THESE ARE NOT TO BE CONSIDERED OFFICIAL POLICY OR TO INDICATE FINAL COURSES OF ACTION BY THE BUREAU OF NAVAL PERSONNEL.

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NEW DEVELOPMENTS RESEARCH DEPARTMENT
PERSONNEL RESEARCH LABORATORY
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WASHINGTON, D.C. 20390

FOREWORD

This study was accomplished under Objective No. 5130401.7, and was prepared at the request of Pers-A41 (Personnel Program Management Division).

Appreciation is expressed to the following commands for their time and cooperation during the preparation stages of this report: Special Projects Office; Experimental Diving Unit of the U.S. Naval School for Deep Sea Divers; and SEALAB II Project.

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ABSTRACT

This report provides the Chief of Naval Operations; Bureau of Naval Personnel; Special Projects Office; Fleet Commanders; and Naval Schools with preliminary information related to the diver personnal and training requirements for the Man-In-The-Sea Program.

This research memorandum discusses projected diver requirements in the Navy and includes a review of existing and anticipated skills and knowledges, depth qualifications, equipment knowledge required, personnel selection prerequisites, hazardous duty implications, NEC and diving pay considerations, types of underwater tasks performed, and new technical skills required.

Comparison of existing versus projected diver personnel and training requirements are discussed and reviewed in light of requirements envisioned for an on-going Man-In-The-Sea effort within the Navy.

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I. INTRODUCTION

A. Purpose

This memorandum presents a discussion of enlisted diver personnel and training implications incident to the deep diving requirements of the Man-In-The-Sea (MITS) Program now underway in the Navy.

The MITS Program will go beyond the present state-of-the-art in Navy diving not only in operating depth requirements for divers, but also in the equipments to be developed for use by divers. This kind of deep diving capability in the Navy is expected to require that existing diver training be modified and that new deep diving NEC's be established for this Program. Other implications requiring investigation and study are increased diver recruitment to meet present and projected needs, hazardous duty requirements, diver retention, and special pay implications.

Based upon initial investigation and study of proposed objectives, the attempt has been made in this memorandum to describe what a MITS diver will be expected to know and what he may be expected to accomplish as a diver who can dive to deep depths and remain there for periods of time from minutes to months.

B. Background

Specific Operational Requirement (SOR) No. 46-19, "Deep Submergence Man-In-The-Sea, Continental Shelf", was issued by the Chief of Naval Operations in October 1964. This SOR sets forth the requirement for a capability in the

Navy to provide the necessary life support and equipment development for the free-swimming diver to accomplish useful work at depths to 600 feet for periods of time from minutes to as long as several weeks or months. System development under SOR 46-19 includes the following:

1. Experimental program in diving physiology.

2. Development and procurement of a portable pressure complex (shipboard decompression chamber which mates with a submersible decompression chamber).

3. Modification of the diving support ship.

4. Development of gas mixing and handling equipment.

5. Development of improved divers' communication systems.

6. Development of improved diving dress.

7. A continued experimental program for extended submergence both in time and depth (Project Genesis).

8. Development of divers' power tools (torque-free types, etc.).

Technical developments for the Man-In-The-Sea (MITS) Program include manned seafloor habitats down to continental shelf depth (approximately 600 feet). An initial step in this direction was made in July 1964 when the Navy conducted SEALAB I in 192 feet of water off the coast of Bermuda. SEALAB I, a steel chamber 40 feet long and 10 feet in diameter, supported four Navy divers. The mission was aborted after 11 days of a planned 20 days on the bottom due to adverse weather and sea conditions.

SEALAB II is the second Navy project to place divers at depth in a seafloor habitat for an extended period of time. This habitat is 57 feet long by 12 feet in diameter and weighs approximately 125 tons (air weight). Current plans call for two or three teams of especially trained divers (approximately ten men per team) to live and work at a depth of approximately 210 feet on the edge of Scripps Canyon. The experiment will last for 30 dyas. Most of the divers will remain at depth for a period of 15 days. Two divers, however, are expected to be selected to remain for the full 30 days.

SEALAB II will be surface supported and monitored from a specially modified staging vessel. This vessel will provide a command and control system for communications, power, life support, gas storage and mixing facilities, handling and hoisting gear, closed circuit TV monitoring, and a decompression complex including a Personnel Transfer Capsule (PTC) with a 10-man capacity.

The PTC, which will be capable of mating with the shipboard decompression chamber, will provide a means of returning the saturated divers to the surface while keeping them under pressure. The divers, after being off-loaded into the decompression chamber, will then undergo the lengthy process of decompression under highly controlled and monitored conditions.

Both SEALAB I (See Figure 1) and SEALAB II (see Figure 2) are but the initial steps toward providing a capability in the U.S. Navy for man to live and perform useful work on the continental shelf. Private U. S. and foreign efforts in this field are also underway.

Future seafloor habitation is expected to include the use of sophisticated equipment systems sufficient to allow self-sustaining seafloor habitation by man for indefinite time periods.

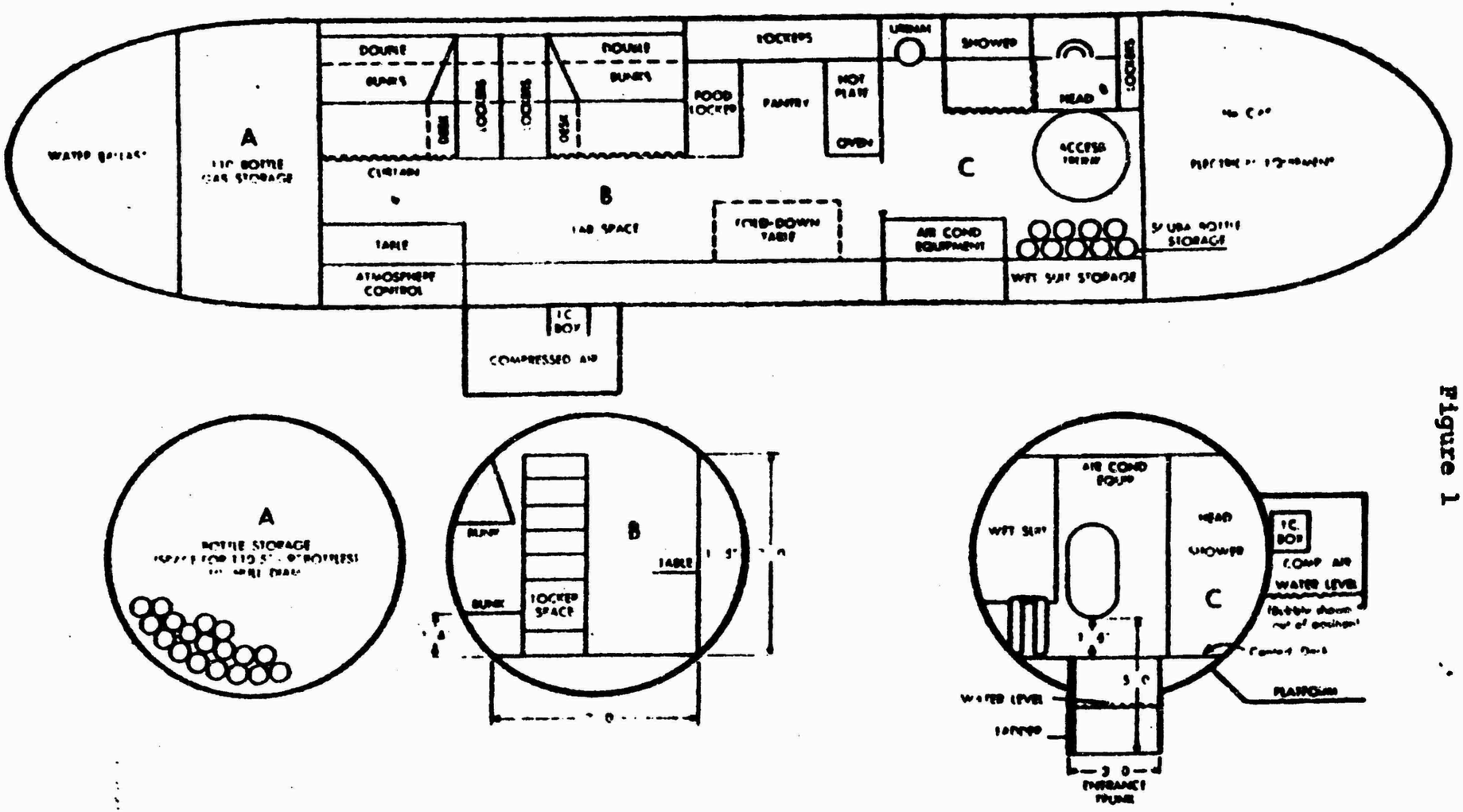
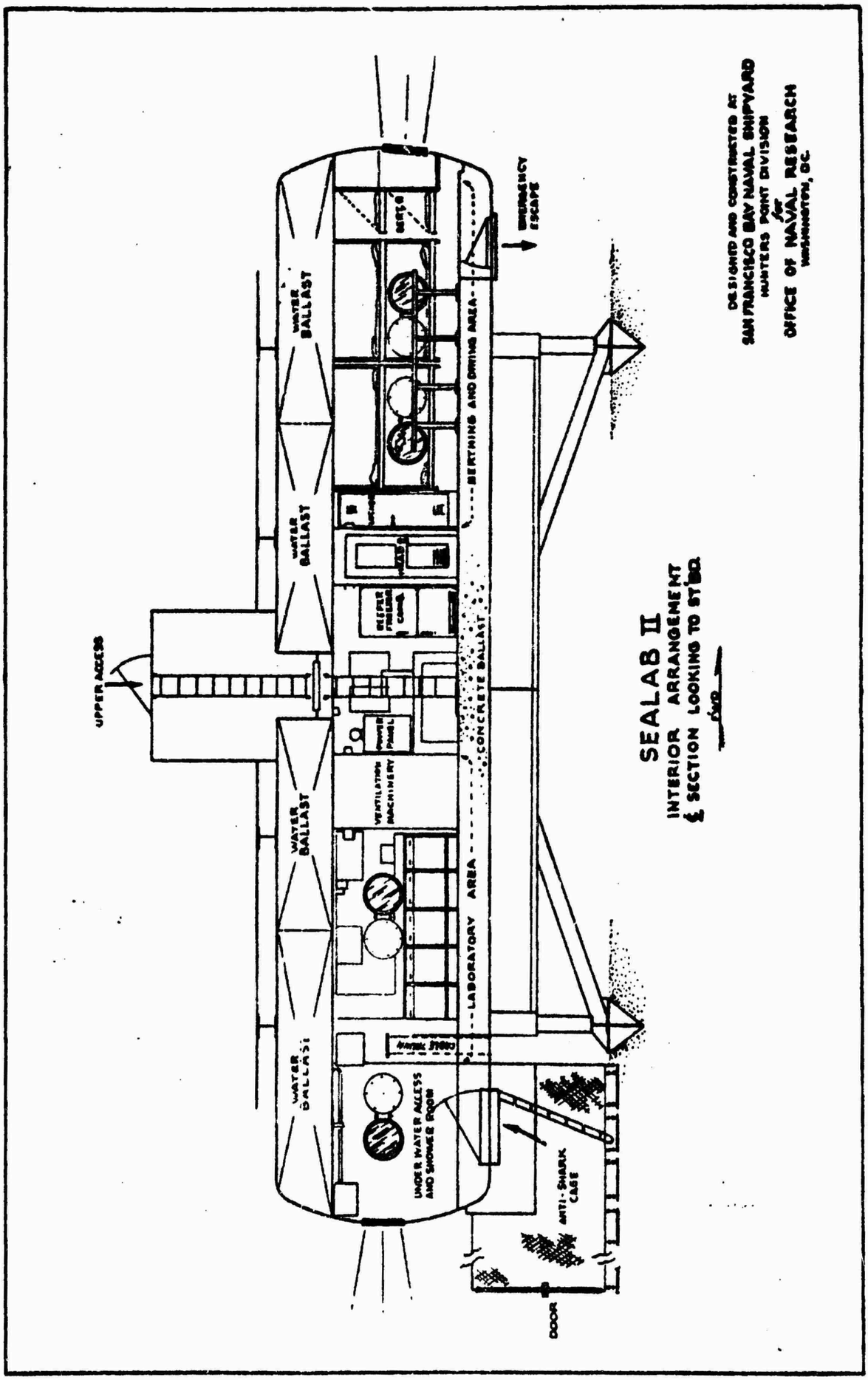


Figure 1

SCHEMATIC DRAWING OF SEALAB I

Figure 2


SEALAB II
INTERIOR ARRANGEMENT
& SECTION LOOKING TO STBD
DESIGNED AND CONSTRUCTED AT
SAN FRANCISCO BAY NAVAL SHIPYARD
HUNTERS POINT DIVISION
for
OFFICE OF NAVAL RESEARCH
WASHINGTON, DC
UPPER ACCESS
WATER BALLAST
WATER BALLAST
WATER BALLAST
WATER BALLAST
BERTHING AND DINING AREA
EMERGENCY ESCAPE
CONCRETE BALLAST
LABORATORY AREA
VENTILATION MACHINERY
UNDER WATER ACCESS AND SHOWER ROOM
ANTI-SHARK CAGE
DOOR

II. APPROACH

Data for this memorandum were obtained by the following procedures:

1. Review of technical and operational data on seafloor habitation (SEALAB I conducted in July 1964, and the forthcoming SEALAB II which will take place in August 1965).

2. Observation of SEALAB II training now in progress (mixed gas scuba portion only).

3. Interviews and conferences with Navy personnel selected to participate in SEALAB II (several also participated in SEALAB I).

4. Close liaison with Special Projects Office which has the responsibility for development of a capability in the U.S. Navy to allow man to occupy and perform useful work on the continental shelf.

5. Discussions on diver training implications for the Man-In-The-Sea Project at the U.S. Naval School, Deep Sea Divers; the U.S. Navy Experimental Diving Unit; and cognizant diver training and qualification offices in the Bureau of Naval Personnel.

6. Determination of training and qualification implications through review of existing enlisted qualifications.

III. GENERAL CONSIDERATIONS

Divers participating in the Man-In-The-Sea Program will be diving to depths which exceed present diver depth limits associated with existing diver qualification requirements in the Navy. SEALAB I and SEALAB II divers were "hand-picked" on the basis of prior experience, quality of past performance, and personal first-hand knowledge of the diver and his capability by the selecting authority.

For SEALAB II and follow-on habitat operations in the Navy, participant divers will be required to use the most sophisticated and reliable SCUBA (semi-closed or closed) available to the Navy. The Mark VI (semi-closed) SCUBA will be used by SEALAB II participants. Future habitat operations are likely to make use of closed-circuit SCUBA which have an O_2 sensor and regulator system.

Present day surface-supplied and diver tending methods ("hard-hat" diving) will not have a direct application to MITS free swimmer requirements. For the most part, existing diver tending systems which require that the diver be tethered to the surface will not have a direct application to seafloor habitat operations. However, habitat divers will use the Hookah System which provides for tethered breathing (similar in principle to surface supplied diving) of the habitat's atmosphere for short sorties in the immediate vicinity of the habitat.

SEALAB I and SEALAB II, which represent the early developmental stage of seafloor habitation techniques (design and development) in the Navy, will require surface support and monitoring. This will be accomplished by means

of umbilical supply and monitoring cables from a surface support vessel to the habitat. Future seafloor habitats, capable of operation independent from surface support, are planned for development.

Operation and maintenance of future manned seafloor habitats will require that divers possess technical skills and knowledges which go beyond present-day diving operational requirements. These projected skill requirements are expected to include operation and maintenance of sophisticated electronic equipments, advanced life support systems (possible decomposition of water as a source of oxygen for prolonged habitat operations, etc.), and autonomous underwater power sources (may be nuclear type).

A means of transferring divers to and from great depths, while keeping them under constant pressure, will be required. For this purpose a Personnel Transfer Capsule (PTC) or Submersible Decompression Chamber (SDC) will be used. These equipments will be designed to permit mating with a shipboard decompression chamber, allowing lengthy decompression of saturated* deep divers under optimum controlled conditions topside. A PTC is now being fabricated for use during SEALAB II operations which will accommodate 10 divers.

*A diver is saturated at a given depth (pressure) when his body has dissolved all the inert gas it can hold in solution at that depth. A reduction in depth (pressure) reduces the amount of gas held in solution and creates a physiological hazard if sufficient decompression time is not allowed.

Present plans include the use of a modified diving support ship for the Man-In-The-Sea Program. This ship is now assumed to be an ASR (Rescue) type. Divers to man the habitat operations planned for this program will be included in the ship's allowance for divers. This plan may require substantial revision as specific mission requirements for the support ship are finalized.

For SEALAB II surface support, a specially modified surface support vessel will be supplied by the U. S. Naval Ordnance Test Station, China Lake, California.

IV. DISCUSSION

A. Diver Qualifications

Diver personnel for MITS operations will be continuously subjected to dangers and hazards created by human psychological and physiological limitations and the inherently hostile environment of the deep ocean in which they must operate. MITS divers will need a working familiarity with new and improved diving apparatus. As more advanced diving apparatus becomes acceptable for use, these divers can be expected to be the prime users. MITS divers must become familiar with the principles of deep diving and their practical application to habitat operations on the ocean floor. A significant amount of electronic and other technical skills is sure to become a diver skill requirement for future seafloor habitat operations. Included in these new diver skills required will be electronics, sonar, and ocean sciences knowledge sufficient to accomplish deep ocean missions.

B. Experience

One of the more important factors in the selection of diver candidates for the MITS Program will be the quality of diving experience required of the applicant. Discussions with Navy diving authorities and with SEALAB II divers indicate that a minimum of two years "active" fleet experience as a qualified diver should be required as part of any set of eligibility criteria for MITS Program candidates. Development of minimum in-the-water time experience requirements should be specified (i.e., 200 UDT water hours) to define "active" fleet experience.

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reason being a lack of sufficient formal training in both diving theory and practical applications. Training for diving NEC's other than Diver First Class provides very little or no instruction in mixed gas diving and these divers are therefore limited by their qualification to relatively shallow depths where use of oxygen-air breathing is applicable. Other reasons cited include insufficient training in the theory and practice of decompression, lack of training in salvage techniques, and use of underwater tools and equipment.

C. Future Diver Qualifications Implications

Navy divers who volunteered and have been selected as SEALAB II participants run the gamut of existing diver types. All have had considerable experience as Navy divers. Two of SEALAB II divers also participated in SEALAB I conducted in July 1964. Although some of the SEALAB II divers are not Diver First Class qualified, they are a hand picked group of divers and all will receive extensive specialized training in the use of mixed gas semi-closed SCUBA (Mark VI), SEALAB II equipment systems, underwater navigation and underwater tools and equipments as required. They will be diving to and remaining at depths exceeding the present depth limitations associated with diver NEC's other than Diver First Class. Considering these factors, present and follow-on Man-In-The-Sea diver qualifications include the following areas:

1. NEC Requirements

Discussions with various diving authorities and with persons directly cognizant of planned SEALAB II operations indicate that diver skills and knowledges required by the Man-In-The-Sea Program cannot be categorized and identified by existing diver classifications Classification of free-swimming divers with the depth capabilities

envisioned for the MITS Program are not defined by existing diver NEC's. Habitat diving operations, whether experimental or follow-on operational applications, will require new procedures and skills not heretofore required in the Navy. Such knowledges and skills include principles of underwater habitation; operation and maintenance requirements of seafloor habitats; bottom search and navigation procedures; use of self propelled, torque-free diver tools; oceanographic knowledges sufficient to complete a deep ocean mission; and knowledges of depth disorientation phenomenon.

Diver First Class qualification now lacks sufficient mixed gas SCUBA training in comparison to "hard-hat" surface-supplied diving. Also, operation and maintenance of submersible decompression chambers is not yet a requirement for Diver First Class qualification or any other diver NEC. However, as described earlier, Divers First Class training and experience, as compared to other existing diver qualification, is generally considered by diving experts contacted to be the more desirable background for MITS type diver requirements. This type diver candidate for the MITS Program has a decided advantage in the area of mixed gas diving (theory and practice), the physics of diving, and is more knowledgeable of salvage and underwater work techniques and tools. The more comprehensive training received by this type diver would tend to better insure, that upon qualification as a MITS habitat diver, he would be a more competent and knowledgeable deep diving team member with more potential for meeting emergency situations at depth.

Discussions with SEALAB II officers and enlisted personnel indicated that acceptance for the MITS Program should include the following:

a. A minimum of two years active Fleet diving experience (will require further definition of "active").

b. Diving competency sufficient to indicate eligibility and suitability for deep depth mixed gas diving planned for the MITS Program.

c. Demonstrated ability to function as a reliable team diver.

d. Be interviewed and thoroughly screened by MITS training authorities to ascertain diving aptitude and motivation for the Program.

It is anticipated that, for the foreseeable future, all divers selected for the MITS Program will require comprehensive training in the use and maintenance of mixed gas SCUBA (may be closed or semi-closed type). Therefore, it appears that prior experience and training in mixed gas diving will be required for follow-on MITS Program eligibility. Unique skill and knowledge requirements for MITS divers will include at least the following:

a. Principles of underwater habitation.

b. Habitat operation and maintenance.

c. Bottom search and navigation procedures.

d. Operation and maintenance of self-propelled and torque-free underwater tools.

e. Knowledge of ocean sciences and use of oceanographic equipments and monitors required for prolonged deep ocean diving.

f. Knowledge of depth disorientation and psychophysiological affects associated with deep prolonged diving missions.

g. Theory and use of mixed gas breathing and decompression.

h. Operation and maintenance of submersible decompression chamber which mates with a shipboard chamber.

i. Operation and maintenance of underwater closed-circuit TV, cameras, and lighting equipment.

j. Operation and maintenance of advanced diver communication equipment (existing or under development).

k. Operation and maintenance of diver sonars and navigation equipment.

l. Operation and maintenance of swimmer propulsion units (SPU).

m. Operation and maintenance of advanced SCUBA gear and Hookah breathing system for seafloor habitat operations.

2. Special Pay Implications

Diving pay associated with existing diver qualifications is discussed in Section 2, Part A-4202 of the Bureau of Naval Personnel Manual. It is limited to the rate specifically designated for a particular diving qualification as follows:

Class of Diver	NEC	Diving Pay
Master Diver	5341	$100
Diver First Class	5342	80
Underwater Demolition Team Swimmers	5321, 5322	100
Explosive Ordnance Disposal Tech	5332	80

Class of Diver	NEC	Diving Pay
Diver Second Class	5343	$ 55
SCUBA Diver	5345	55
Underwater Photographer	8136	55
Hospital Corpsman, Special Operations Tech	8492	80
Medical Deep Sea Diving Tech	8493	80

Diving pay is not considered as incentive pay for the performance of hazardous duty, and under current regulations, "no member of the naval service shall be entitled to receive special pay for the performance of diving duty----in addition to incentive pay for the performance of hazardous duty". Diving officers receive $110 per month and enlisted personnel receive diving pay of $55; $80; or $100 per month depending on the type diver qualification held.

Discussions with cognizant persons concerning diving pay and qualification implications for Man-In-The-Sea divers pointed out the following areas of considerations:

a. Standard Diving Pay Rate for MITS Diver

There is considerable feeling on the part of those directly involved in the development of a deep diving capability to continental shelf depths that a separate pay category is needed for divers who are able to qualify as MITS divers. Since Diver First Class pay is $80 per month and UDT swimmers now receive $100 per month (combined jump and explosive pay), it would appear that a MITS

diver pay should at least equal the higher of these two rates. Based upon preliminary investigations, diving pay, in general, will take on greater significance in the future as regards recruitment and retention of sufficient numbers of trained divers for Navy needs.

b. Hazards Assumed

Although many persons directly cognizant of Navy diving feel otherwise, the Navy does not recognize diving as hazardous duty for pay purposes. However, it was pointed out in discussions with diver personnel that civilian life insurance companies, for the most part, are reluctant or refuse entirely to insure divers. Those companies which do insure divers charge a considerably higher rate which is roughly equal to rates charged aviators.

There seems to be a general consensus among diving experts contacted that Man-In-The-Sea objectives do involve hazards and uncertainties for the diver. At the progressively deeper operating depth planned for this Program there are few, if any, predetermined standards or proven operating procedures. Even the yet unknown physiological and psychological limits of man in the ocean are hazards to be assumed by these divers. Once a diver is saturated at a given depth he must not ascend higher than 33 feet from that depth without decompression. Therefore, the hazard exists for a diver who, while accomplishing a task, may accidentally stray to a shallower depth than his saturation depth permits.

Equipment malfunctions or failures at depth, disorientation, bottom currents and water temperatures, emergency abortion of a habitat mission, and developmental decompression schedules associated with deep diving are other areas of implied hazards. Experts in the field feel there are inherent risks, even under the best and most controlled diving conditions. Also, hazards encountered from non-human

inhabitants must be considered. Due to the fact that qualified divers, especially Divers First Class, are in short supply, it appears increased incentives for diving duty will be required. Special pay for the performance of hazardous duty, in addition to authorized diving pay based on qualification, should receive serious consideration in view of increasing diver demands and risks incident to a more effective system of Navy diving.

c. Rating Skills and Advancement

Rating groups now eligible for diving training are limited in scope. Technical rating skills (i.e., electronics, sonar, etc.), are not eligible for diving training unless specific individual waivers are requested.

Rating eleigibility requirements for enlisted diver courses are as follows:

Diver First Class - BM, GM, DC, SF, MR, MM, EN, and EM in pay grade E-4 and above.

Diver Second Class - BM, GM, TM, MN, EN, MR, SF, DC, MM, EM, SW, and BU in pay grade E-3 and above, and SN/FN desiring to pursue one of the aforementioned rates.

SCUBA Diver - Same as Diver Second Class plus PH and HM in pay grade E-4 and above, training for NEC 8136, or NEC 8492.

Medical Deep Sea Diving Tech - HM in pay grade E-5 and above. Class "B" school graduates preferred.

Future diving operations (especially habitat type) will undoubtedly incorporate the use of electronic equipment systems of considerable sophistication.

Such systems are expected to include rating skill requirements for navigation and sonar systems, computer integrated control and monitoring systems, advanced underwater power sources (possibly nuclear), and advanced underwater communications.

Investigation into the question of why diving has not been established as a separate rating revealed the following:

(1) If diving became a separate rating, divers would probably experience even more difficulty in advancement in rating than under existing circumstances. The number of divers in the Navy is relatively small and a new rating would become top heavy and chances for advancement nil.

(2) Under existing training concepts and definitions, diving is a qualification and not a rating skill. Qualification to dive signifies the ability to use a skill to accomplish tasks underwater.

(3) If diving were a separate rating, a diver, who may happen to lose his qualification as a result of medical or other reasons, would not be able to easily assume and learn a non-diving skill. Furthermore, he would not be able to easily convert to a new rating while retaining his same rate and subsequently exhibit the expected competency in that rating at his pay grade.

Many Navy divers, once they become qualified, spend the remainder of their careers in the Navy as divers and not as specialists in their designated rating.

Although the basic knowledge of individual rating can be read from a book, divers who must compete fleetwide for advancement in rating are put at a decided disadvantage. It has been suggested that to give Navy divers a more equitable advancement opportunity, perhaps points could be assigned for years of diving experience similar to points received for medals, awards, years in rate, etc. Loss of experience in a rating could then be somewhat offset by points received for diver qualification and experience.

V. EQUIPMENT TRAINING IMPLICATIONS

Diver training for an on-going Man-In-The-Sea Program will require skills and knowledge which include but may not be limited to the following equipments and apparatus:

A. Mixed Gas SCUBA

Mark VI SCUBA was used for SEALAB I and will be used for SEALAB II. Training for deep ocean operations will require that the diver receive much more familiarization with mixed gas SCUBA than is now offered in existing courses. SEALAB II subjects will receive four weeks intensive Mark VI SCUBA training. It is presently the most advanced mixed gas SCUBA available for use in the Navy but is operationally limited at present to approximately 200 feet. However, more advanced SCUBA than the Mark VI is already in the advanced stages of development. One of these units now under development would provide automatic gas volume and mixture control for any given depth. Mixed gas SCUBA training will require modifications to meet new developments in this type diving gear.

B. Submersible Decompression Chamber (SDC) or Personnel Transfer Capsule (PTC)

This chamber roughly resembles the McCann Rescue Bell (now carried by ASR's) but it will be capable of mating with a shipboard decompression chamber and transporting saturated divers while keeping them under pressure.

It will be used to take divers to a given depth and then return the divers (saturated or non-saturated) to the surface for decompression. The PTC to be used during SEALAB II operations will accommodate approximately 10 divers. The SDC/PTC while necessary to support habitat operations, will also provide the necessary means for teams of divers to be shuttled back and forth from the surface to an underwater work site until a particular task is accomplished. This technique will preclude the need for a habitat operation in every deep depth extended operation depending upon the mission to be accomplished.

Diver training authorities have indicated that training for personnel to operate an SDC/PTC should be similar to that required by the McCann Rescue Chamber which is currently included as part of existing Diver First Class training.

C. Swimmers Propulsion Units (SPU)

There are numerous types of swimmers' propulsion units available for both civilian and military purposes. These free flooding (wet) vehicles now include one to four-man craft. The Navy has in use a variety of these vehicles — most are used by Underwater Demolition Teams.

For the Man-In-The-Sea Program both wet and dry swimmer propulsion units will be required. Dry pressure-cabin craft will be required where transit of diver personnel over bottom terrain having depth decreases greater than 30 feet is necessary. A saturated diver cannot safely withstand such a pressure differential without decompression or means of pressure compensation.

For SEALAB II, plans now include the use of the Mark I propulsion unit. This vehicle will accommodate up to two divers riding in a prone position. It can be easily modified to provide for increased maneuverability by using control surfaces similar to that on airplanes.

Swimmers' propulsion units and underwater craft are sure to play a larger role in follow-on Man-In-The-Sea operations. Diver work sorties will expand farther from the habitat and underwater currents may not permit unassisted free swimming by the diver.

D. Diving Suits and Cold Water Protection

Electrically heated suits are expected to be used and tested by SEALAB II subjects. An effective means of protecting the diver against the serious consequences of excessive body heat loss during prolonged exposures at depth is required. Training in the use and maintenance of such suits is not expected to require lengthy or prolonged instruction. As new development diving dress becomes Fleet accepted, training for its use and maintenance will become incorporated into appropriate diver training courses.

E. New Underwater Tools and Equipment

The use of SCUBA type diving gear, although providing the diver greater mobility, imposes certain disadvantages to the accomplishment of underwater tasks. SCUBA divers are not easily able to anchor themselves in order to apply a pressure or mechanical force against objects or counteract a force which may be brought to play against their bodies. This fact is due to the lack of

sufficient means for the SCUBA diver to anchor himself to the bottom unless he wears excess amounts of weight. To walk the ocean floor is extremely difficult for a SCUBA diver.

Power tools designed for use underwater will require not only that diver anchoring techniques be improved, but also that tools used be as near torque and recoil-free as possible. Advanced power velocity tools, such as explosive stud drivers, are already under development.

F. Sonar and Navigation Equipments

Small sonar units and navigation equipments such as small beacons and pingers have been in use by EOD and UDT swimmers for sometime. These equipments include hand held sonars (AN/PQS-1 series are examples), and small pingers for bottom navigation (Mark 16 type or similar). Both types of equipment are likely to be used during SEALAB II operations.

The AN/PQS-1B hand held sonar has a range of up to 120 yards, can be operated in active or passive modes, and weighs 22 pounds in air (one-half pound positive bouyancy). Its doughnut-shaped printed circuit is powered by regular flashlight batteries.

Small beacons, now available as diver navigation and location aids, are easily attached to underwater vehicles, or underwater structures, and can be carried or worn by the diver.

G. Swimmer's Depth Monitor

Upon becoming saturated at a given depth, a diver cannot swim to a lesser depth without risking serious

physiological consequences or even death. To prevent depth-altitude wandering of more than one atmosphere (33 feet), the diver must have the necessary means to monitor his depth. Future depth monitors are expected to produce audible, optical, or other sensory warning outputs when one atmosphere differential is reached.

H. Protective Equipments

Improved techniques and/or equipments will be required to provide the diver with a means of protection against hostile marine life capable of inflicting serious injury or death to the unprotected diver. Divers are only able to muster a minimal defense, at best, should they find themselves under attack by any of several vicious and unpredictable marine animals.

I. Underwater Communications Equipment

Existing underwater communication equipments do not yet provide for adequate diver communications. Equipment development will be required to provide two-way voice communications. These equipments will be capable of minimizing human voice distortion inherent in a helium atmosphere. Under these conditions the human voice becomes very high-pitched.

Some diver-to-diver audio communications are now available, but they are generally applicable only to air-oxygen diving. New development systems will be required which can be used with HeO_2 gases. There are several prototype equipments which attempt to unscramble the helium voice distortion. Diving authorities contacted on this subject feel that such equipments have potential for operational use.

J. Closed Circuit TV, Cameras, and Lighting Equipments

These equipments are necessary to any sea-loor habitat operations for recording and monitoring purposes. TV cameras will require the diver to know installation procedures, use and checkout of this equipment. Underwater cameras and lighting systems are well within existing skills and knowledges. Rating skills possessed by Electronics Technician (ET), Interior Communications Technician (IC), and Electricians Mate (EM), for example, cover the scope of skills required for these equipments.

However, under existing regulations, most of the electronics and electrical ratings are not eligible to receive diving training. For the equipments cited above, and for follow-on underwater electronic skills requirements in the MITS Program, there will be a need to open diving training to electronics ratings.

K. Oceanographic Instruments and Equipment

Man-In-The-Sea divers which may include professional oceanographers will require skills and knowledges associated with bottom mapping, underwater search, use of current monitoring devices, knowledge of the characteristics of ocean layers, light transmission and dispersion in the sea, and knowledge sufficient to conduct any necessary geological missions required (location of seafloor fresh water supplies, bottom composition sampling, etc.).

L. Salvage Skills and Knowledges

The MITS Program will provide the knowledge and means of placing divers to continental shelf depth

ranging in time from minutes to weeks or months. Technical and medical experts associated with development of this diver capability estimate that, depending upon the job to be done and the diving facilities required, one habitat diver may be able to equal the effort of a number of surface tended divers. Further study of these implications for deep water salvage operations will be required. Under the Deep Submergence Systems Project (DSSP), a large object salvage capability to continental shelf depth will be developed under SOR 46-17 and ADO 46-18X. Development of this capability is directly dependent upon the MITS Program's demonstrating man's ability to do useful work down to the continental shelf and perhaps farther.

Salvage divers of the MITS type will require a working familiarity in the latest salvage techniques and procedures. Specialized salvage training for continental shelf depths will require emphasis upon collapsible pontoons (under development) varying in sizes up to 100 tons lift capacity; use of diver held power tools (including power velocity type); diver positioned explosives, and lifting attachments; bolting and embedding equipments, and advanced cutting and welding tools; and use of new hull-dewatering techniques and equipments.

Salvaging large objects at deep depth will also require skills and knowledges to effectively salvage embedded objects on the ocean floor. Also required will be a working knowledge of the methods and equipments necessary to overcome bottom breakout forces.

Future salvage diver training may also include the use of a seafloor habitat (salvage hut) similar to the habitat developed for the MITS continental shelf Program. Use of a Personnel Transfer Capsule or Submersible Decompression Chamber to permit the transfer of saturated and non-saturated divers to the surface will be required for deep salvage operations.

VI. CONCLUSIONS AND RECOMMENDATIONS

This preliminary survey of Man-In-The-Sea diver requirements and implications to be drawn for the future has brought to light several factors which appear to warrant immediate or near future action:

1. Action to establish a new NEC for MITS divers and subjects should be initiated. No single existing diver NEC fully covers the scope of diving qualifications required by this deep ocean diving program.

2. For qualified MITS divers, diving pay received while filling a MITS billet should be standardized and independent of qualification and diving pay rate prior to qualification for the MITS Program. While serving in MITS billets, divers should be paid at a rate appropriate to the duties and responsibilities of billets being filled.

3. Candidates should be selected from among best qualified divers available. The consensus among diving training authorities indicated that existing Diver First Class (5342) training and experience best meets the MITS diver background requirements. The aspects of this diver qualification considered most valuable to the MITS Program include the theory and use of mixed gases; decompression using mixed gases, and use of decompression tables and schedules; and training in salvage diving and techniques.

4. Minimum Fleet experience as a qualified diver for MITS eligibility should be two years active diving duty and demonstration of better than average diving "know-how".

5. Rating eligibility for diving training should be modified to include those possessing electronics and electrical skills and knowledges. The MITS Program development is certain to include a trend toward more sophisticated underwater electronics which involve the use of divers for operation and maintenance.

6. Further studies into diving incentives and motivation are required. At present, diver requirements in the Navy far exceed available outputs from training pipeline sources.

7. Although not now officially recognized as such in the Navy, diving experts point out that diving duty is a hazardous occupation even under the best of conditions. Incentive pay for the performance of hazardous duty should therefore receive all due consideration in light of seriously lacking incentives for Navy personnel to volunteer for diving duty. Hazardous duty pay in addition to diving pay should be an important first step toward increased diver candidate recruitment and retention.

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13. ABSTRACT

This report provides the Chief of Naval Operations, Bureau of Naval Personnel, Special Projects Office, Fleet Commanders, and Naval schools with preliminary information related to the diver personnel and training requirements for the Man-in-the-Sea Program, and was prepared at the request of Pers-A41(Personnel Program Management Division).

This research memorandum discusses projected diver requirements in the Navy and includes a review of existing and anticipated skills and knowledges, depth qualifications, equipment knowledge required, personnel selection pre-requisites, hazardous duty implications, NEC and diving pay considerations, types of underwater tasks performed, and new technical skills required.

Comparison of existing, versus projected diver personnel and training requirements are discussed and reviewed in light of requirements envisioned for an on-going man-in-the-sea effort within the Navy.

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